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WORKING MEETING ON METEOROLOGICAL AND DIFFUSION CHARACTERISTICS IN WOODED AND URBAN DOMAINS IN COMPLEX TERRAIN

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WORKING MEETING ON METEOROLOGICAL AND DIFFUSION CHARACTERISTICS IN WOODED AND URBAN DOMAINS IN COMPLEX TERRAIN

JANUARY 1983

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On 16 and 17 November 1982, the US Army Atmospheric Sciences Laboratory (ASL) at White Sands Missile Range, New Mexico, conducted a working meeting on meteorological and diffusion characteristics in wooded and urban domains in complex terrains. The working meeting addressed the generation of a comprehensive meteorological database in wooded and urban domains in complex terrain. Such a database is needed for developing, testing, evaluating, and validating integrated mesoscale-microscale models. The general recommendation

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of the working meeting was that the ASL and the Forest Service initiate, organize, and conduct a cooperative field study for the project. During the meeting, recommendations were made concerning the basic criteria for selection of a field site and variables to be monitored. Preliminary suggestions were submitted on measurement techniques, instrumentation, tentative field sites, management and coordination of the field program, and future activities.

FOREWORD

The working meeting on meteorological and diffusion characteristics in wooded and urban domains in complex terrain resulted from recognizing the pressing need for the creation of a comprehensive and unified database. This need is common to US Army Atmospheric Sciences Laboratory and Forest Service and, hence, the feasibility of conducting a cooperative field study was explored. It should be noted that while the working meeting was initiated by the Atmospheric Sciences Laboratory and while this summary report is an Atmospheric Sciences Laboratory document, the conduct of the working meeting was a joint effort with the Forest Service. The deliberations and recommendations of this working meeting are a fine example of earnest cooperation among scientists and of their resolution to collaborate in fulfilling the mutual needs of the Atmospheric Sciences Laboratory and the Forest Service.

EXECUTIVE SUMMARY

Generation of a comprehensive and unified database on meteorological and diffusion characteristics in wooded and urban domains in complex terrain through a cooperative field study between the US Army Atmospheric Sciences Laboratory and the Forest Service was addressed by the working meeting. This database is needed for development, testing, evaluation and validation of integrated mesoscale-microscale models. The general recommendation of the working meeting is that *a cooperative field study between the US Army Atmospheric Sciences Laboratory and the Forest Service on meteorological and diffusion characteristics in wooded and urban domains in complex terrain should be initiated, organized and conducted.* Recommendations concerning the basic criteria for selection of a field site and variables to be monitored are advanced. Preliminary suggestions regarding measurement technique and instrumentation, tentative field sites, management and coordination of the field program, and future activities are submitted. An acting Steering Committee composed of R. M. Cionco (ASL), D. G. Fox (RMF&RES) and W. Z. Sadeh (CSU) was appointed and charged to pursue the activities initiated at this working meeting. A second working meeting, which will primarily focus on synthesizing the various objectives and approaches into an integrated plan for the field study, will convene at Pacific Southwest Forest & Range Experiment Station, Riverside, California, on 30-31 March 1983.

TABLE OF CONTENTS

	Page
FOREWORD	iii
EXECUTIVE SUMMARY	iv
1. INTRODUCTION	1
2. GENERAL LECTURES	2
2.1 Army Needs in Meteorology and Diffusion in Complex Terrain, R. M. Cionco, Atmospheric Sciences Laboratory	2
2.2 Overview of Forest Service Atmospheric Sciences Needs, D. G. Fox, Rocky Mountain Forest and Range Experiment Station	4
2.3 Research Opportunities in Meteorology and Diffusion in Complex Terrain, W. Z. Sadeh, Colorado State University	4
3. CURRENT/PLANNED RESEARCH PROJECTS	7
4. DELIBERATIONS	11
5. FIELD STUDY	12
5.1 Requirements	12
5.2 Variables	12
5.3 Measurement Technique	13
5.4 Field Sites	14
5.5 Management and Coordination	15
5.6 Future Activities	16
6. CONCLUDING REMARKS	18
APPENDIX I Roster of Participants	19
APPENDIX II Agenda	21
APPENDIX III Questionnaire	23
APPENDIX IV Field/Modeling Study Matrix Form	25

1. INTRODUCTION

A working meeting on meteorological and diffusion characteristics in wooded and urban domains in complex terrain was conducted at the US Army Atmospheric Sciences Laboratory in White Sands Missile Range, New Mexico, from 16 to 17 November 1982. Funds for the working meeting were provided by the Atmospheric Sciences Laboratory. The working meeting addressed the generation of a comprehensive meteorological database in wooded and urban domains in complex terrain. Such a database is needed for development, testing, calibration, evaluation and validation of integrated mesoscale-microscale models. In view of the similar meteorological needs of Atmospheric Sciences Laboratory (ASL) and Forest Service (FS), the working meeting focused on the feasibility of a cooperative field study devoted to producing the needed database. Specifically, the objectives of the working meeting were to:

1. define the goals of a cooperative field study;

2. identify the research conducted in various laboratories;

3. review the capabilities of various laboratories;

4. discuss preliminary planning of a cooperative field study.

A summary of this working meeting is reported in this document.

The working meeting was initiated by the Atmospheric Sciences Laboratory (ASL), White Sands Missile Range, New Mexico, and was organized in cooperation with Forest Service Rocky Mountain Forest and Range Experiment Station (RMF&RES), Fort Collins, Colorado, and Colorado State University (CSU), Fort Collins, Colorado. The steering committee of the working meeting consisted of R. M. Cionco (ASL), D. G. Fox (RMF&RES) and W. Z. Sadeh (CSU). In order to maintain a single discussion group, the number of participants was small. A total of fifteen scientists attended the working meeting; six from Army Laboratories, seven from Forest Service, one from H. E. Cramer Company (Army Contractor), and one from Colorado State University (Forest Service Contractor). The roster of participants is given in Appendix I.

The working meeting lasted for two days, and the agenda is given in Appendix II. During the first day, three general lectures were delivered by R. M. Cionco, D. G. Fox and W. Z. Sadeh, and short informal presentations on ongoing/planned research projects were delivered by each participant. The second day was devoted to general discussions on requirements that a field study has to meet, parameters that have to be measured, measurement technique and instrumentation needed for conducting a field study, tentative field sites, and tentative organization structure of a cooperative program between the Atmospheric Sciences Laboratory and Forest Service.

2. GENERAL LECTURES

Three general lectures were presented in the first session on 16 November 1982 by R. M. Cionco, D. G. Fox and W. Z. Sadeh that addressed the Army needs, Forest Service needs, and research opportunities in meteorology and diffusion in complex terrain. No attempt is made to include in this report the entire lectures. Rather, the main points of these three lectures are briefly summarized below to provide an overview of the objectives of the working meeting.

2.1 Army Needs in Meteorology and Diffusion in Complex Terrain, R. M. Cionco, Atmospheric Sciences Laboratory

This lecture focused on ASL long-range research program on modeling meteorological and diffusion characteristics in wooded and urban domains in complex terrain. Such research is needed by the Army in support of: (1) chemical defense modeling, (2) tactical weather intelligence, (3) smoke and other obscuration episodes, and (4) simulation of characteristics and influences of generic vegetations and urban domains on battlefield environments and scenarios. The ultimate goal of the research program is the development of integrated high-resolution mesoscale-microscale model(s) capable of simulating wind fields within and above vegetative canopies and urban domains in complex terrain. Successful completion of this research program is contingent upon adopting a systematic approach consisting of the following four major phases: (1) development of models for each domain; (2) coupling of individual meso- and micro-scale models; (3) a field study devoted to collection of data within meso- and micro-scale ranges; and, (4) testing, evaluation and validation of integrated (or coupled) model(s).

Cionco next briefly reviewed the research work on airflow in canopy and urban domains and in complex terrain presently underway at ASL. The research work on airflow in vegetative domains currently concentrates on: (1) meteorological characterization, (2) synthesizing of canopy-coupled surface layer wind model and numerical schemes, (3) development of methods to estimate turbulent diffusion coefficients for a variety of canopies and corresponding boundary layers, and (4) initiation of a cooperative field study with the Forest Service to be conducted in FY (fiscal year) 1985. As far as wind field in urban domains is concerned, studies are being initiated using an idealized urban domain. Such an idealized urban domain consists of an inner city surrounded concentrically by an industrial area, suburban area and rural area. The objectives of these studies are: (1) characterization of urban domains; (2) development of methods to evaluate turbulent diffusion coefficients; and, (3) identification and compilation of meteorological databases for world-wide urban areas. Similarly, studies on wind fields in complex terrain concentrating on air-earth interactions and on improvement of surface-layer wind models are also being initiated.

Next, the goals of the research at ASL during FY 1983 were outlined. These goals are: (1) continuation of implementation and testing of canopy-coupled surface layer wind model and software development; (2) evaluation of methodologies for estimation of turbulent diffusion coefficients; (3) synthesizing of urban-coupled surface layer wind model; (4) completion of urban areas database; (5) refinement of canopy database; (6) development of complex terrain database; (7) improvement of orographic flow model;(8) initiation of synthesis of hierarchy of complex terrain models; (9) continuation of meetings on the cooperative field study; and, (10) initiation of modeling of airflow over and through canopy edges.

The basic objectives of canopy airflow modeling are to define the vertical wind and temperature profiles within the canopy, immediately above the canopy, within the boundary layer above the canopy, and to estimate the variation of the turbulent diffusion coefficients. In addition, one needs to characterize the terrain surface, leaf temperature, and to account for diurnal and seasonal changes. Meteorological parameters needed to conduct this modeling are wind profile, ambient temperature, atmospheric stability, canopy flow index, canopy vertical leaf area silhouette, canopy coupling ratio parameter, and turbulent diffusion coefficients.

The basic features of a canopy-coupled surface layer wind model and associated computer graphics presently employed at ASL were reviewed. This is a steady state, two-dimensional model based on Gauss principle of least constraints that applies over warped surfaces. of complex terrain, accounts for terrain curvature effects upon the flow, has a basic grid resolution of 100 m (which can be varied from 60 to 400 m), and uses a variational relaxation technique.

Next, Cionco stressed the availability of a database inside and above a forest canopy and in a clearing that was collected during a field study at Fort Polk, Louisiana, in April 1980. This data has been partially reduced and the analysis is not yet completed.

The basic goals of modeling of airflow in urban domain initiated at ASL, and the meteorological parameters of importance in flow in urban domain were next briefly summarized. Goals of this modeling are to: (1) define the vertical wind and temperature profiles within urban area, immediately above urban roughness in the adjacent surface boundary layer, and in the upper region of the planetary boundary layer; (2) determine the fetch associated with each land-use category; and, (3) estimate the turbulent diffusion coefficients. Meteorological parameters of significance in an urban domain are wind speed and direction, ambient and surface temperature, mixing depth, atmospheric stability, relative humidity, and turbulent diffusion coefficients. The need for the development of a land-use classification scheme which accounts for meteorological anomalies, consistent with that used by NATO, and of universal nature was stressed. In addition, the pressing need for the generation of a database on flow in urban domain was emphasized since urban data of interest is almost nonexisting.

In concluding the lecture, Cionco stressed the mutual needs of Atmospheric Sciences Laboratory and Forest Service in producing a database and the feasibility of a cooperative field study to meet these needs.

2.2 Overview of Forest Service Atmospheric Sciences Needs, D. G. Fox, Rocky Mountain Forest and Range Experiment Station

This lecture provided an in-depth background on the Forest Service Program in Atmospheric Sciences and on the prospects for future research work. In presenting this background information, Fox relied on the Proceedings of the Forest Service Atmospheric Sciences Research and Application Workshop held in Denver, Colorado, from 18 to 20 May 1982. This workshop was attended by over 50 researchers, operational users of meteorological information, and managers. The workshop divided into four working groups-viz., air management, fire management, snow, soil and water management and user. A primary recommendation of this workshop was the need for operational collection, archiving and dissemination of meteorological data and information. A second basic theme was the need for researchers to provide the meteorological information to the user community in a more efficient manner.

The current research capabilities in the Forest Service in atmospheric sciences were next briefly outlined. Specific meteorological projects are being conducted at Macon, Georgia, Riverside, California, and Fort Collins, Colorado. At Macon Laboratory the research concentrates on the Southeast area, at Riverside the research is associated with situations characteristic to Southern California, while the Fort Collins group works on meteorological situations across the country. Researchers in other locations (e.g., Missoula, Montana, Portland, Oregon) work in fire and smoke management activities. Next, Fox emphasized that distributive computer processing of data in combination with Remote Automated Weather Systems (RAWS) planned by the Forest Service can lead to an efficient dissemination system of meteorological data.

In concluding the presentation, Fox stressed the commonality of high-priority meteorological problems between the Atmospheric Sciences Laboratory and Forest Service, and the need for a cooperative field study. He further stressed that such a joint effort can provide a meteorological database which can meet the needs of both organizations.

2.3 Research Opportunities in Meteorology and Diffusion in Complex Terrain, W. Z. Sadeh, Colorado State University

This lecture focused on basic research problems in meteorology and diffusion in vegetative canopies and urban roughness in complex terrain. At the present time, the fundamental knowledge of wind fields in complex terrain is quite sketchy and inadequate, quantitative analysis is limited to specific simple cases and spotty, and the credibility of results is limited due to the oversimplifications applied in obtaining them. The flow conditions in complex terrain are primarily determined by the terrain configuration and the particular roughness structure

for given terrain. Natural roughness (i.e., vegetative canopies) and man-made roughness (i.e., urban domain) affect the flow differently, everything else being the same. Long-term averaged values of meteorological parameters currently used cannot provide an appropriate and meaningful description of local effects induced by terrain-roughness combination such as rapid changes over short distances, variability and extreme cases, to mention a few. These effects are not reflected in long-term averages and, consequently, one needs to identify appropriate averaging scales for each class of complex terrain-roughness combination.

Two wind scales, viz., meso and micro, are at the present time considered in model development. In view of the major importance of terrain-roughness combination, it is apparent that one needs to divide the microscale range into two subscale, regional and local subscales. Such a division will permit to adequately account for the local effects in any model. Exploration of this scale division in model development was suggested. As far as development of integrated model(s)-viz., mesoscale-microscale coupled model- is concerned, a systematic approach was outlined. Such an approach consists of development of: (1) separate models for each scale-local, regional and meso; (2) partial coupling of the individual models; and, (3) full coupling. The coupling depends upon the meteorological conditions and the given terrain-roughness combination. Investigation of this approach in model development was proposed.

Modeling of turbulence, temperature distribution and stratification in complex terrain is currently in its infancy stage. In order to improve the modeling, it was stressed that one first needs to investigate these aspects in complex terrain in the absence of roughness. Then a second generation of models in which surface roughness is incorporated are to be developed based on the successful completion of the first stage.

In order to adequately account for the terrain-roughness combination, the pressing need for mathematical characterization of complex terrain and surface roughness was emphasized. In attempting to mathematically characterize the complex terrain, one needs to introduce at least three basic classes according to the terrain change and degree of complexity, e.g., slightly, moderately and highly complex in a similar manner as surface roughness is divided in very fine, fine and high categories. To date, a mathematical characterization of complex terrain and of complex terrain-surface roughness combination has not been yet undertaken despite its prime significance for both vegetative and urban domains. Development of a mathematical characterization will permit to assess the influence of each class of complex terrain-surface roughness combination upon the flow.

An issue of prime interest is whether one can achieve a universal model for any given terrain-roughness combination and meteorological conditions. The major role played by the terrain-roughness combination indicates that the possibility of a universal model(s) is slim. Efforts should be invested in developing specific models for given terrain-roughness situations.

Next, Sadeh stressed the role of physical modeling in a meteorological wind tunnel of airflow in complex terrain. At the present time, physical modeling over local scale in vegetative and urban domains can be accomplished. Such a physical simulation can provide a wealth of data for the user community, and can be used for model development and validation. Physical modeling over regional scale is not yet feasible due to the lack of an adequate wind tunnel. The need for the construction of a wind tunnel capable of simulating flow within both local and regional scales was stressed.

The present methods used in modeling turbulent transport processes was briefly reviewed. Currently, the basic three approaches are: (1) transfer theory or K-theory; (2) statistical analysis; and, (3) gaussian analysis. The deficiencies associated with each approach were pointed out, and the need for fundamental research on turbulent transport was emphasized.

Development of realistic models is contingent upon the availability of a sound database. The lack of a comprehensive database on flow in wooded and urban domains in complex terrain is evidently the major obstacle in achieving the badly needed advancement in modeling. To this end, it was stressed that one cannot expect significant improvement in modeling without producing an encompassing database.

In concluding the lecture, Sadeh strongly emphasized the evident commonality of the need for a meteorological database of the Atmospheric Sciences Laboratory and the Forest Service. The realization of the proposed cooperative field study can provide the stimulus and basis for a quantum improvement in basic and applied research, and in modeling of airflow and turbulent transport in complex terrain.

3. CURRENT/PLANNED RESEARCH PROJECTS

A brief summary of the research projects currently conducted by the participants is outlined below. This summary is compiled based on the short presentations delivered during the second session and on answers to a questionnaire. A sample of this questionnaire is provided in Appendix III. In addition, the instrumentation capability of each laboratory is listed.

1. J. E. Deeming, Forest Service, Pacific Northwest, Portland, Oregon

Current/Planned Research: Analysis of smoke concentration with particular emphasis on residual smoke and smoke entrainment in down-canyon nocturnal flows, and the determination of a critical smoke concentration level. At this time, use of an off-the-shelf model that incorporates air drainage is envisioned.

Short Description: Field data is collected at two sites and tethersonde balloon surveys are conducted during strong drainage situations. Monitoring of smoke entrained in down-canyon flow was conducted to date in two field burning studies.

Instrumentation: Two remote automated surface stations; the purchase of a tethersonde balloon system is planned.

2. J. W. Barry, Forest Service, Forest Pest Management, Davis, California

Current/Planned Research: Characterization of atmospheric conditions which promote deposition of aerial spray on target and which minimizes spray drift off target, and identification of measurements and instrumentation required to collect relevant meteorological data.

Short Description: Development of an Aerial Spray Planning and Analysis System (APAS) has been initiated. This system is currently based on the Forest Service Cramer/Barry/Grim (FSCBG) computer program.

Instrumentation: None, usually it is provided by the contractor and/or cooperator.

3. M. A. Fosberg, Forest Service, Pacific Southwest, Riverside. California

Current/Planned Research: Development of a three-dimensional mass consistent momentum transport model in complex terrain with a grid size of 1 to 10 km over a horizontal extent from 200 to 500 km.

Short Description: This model is based on Livermore MATHEW model and Japanese Meteorological Service momentum model. A field study specifically conceived for momentum transport in Southern California is planned in FY 1983.

Instrumentation: Field portable rawinsonde, monostatic acoustic sounder, laser anemometers, tethersonde balloon, tracking radar multiple tetroon system, surface recording weather stations.

4. F. A. Albini, Forest Service, Northern Forest Fire Laboratory, Missoula, Montana

Current/Planned Research: Modeling of behavior of crown fires considering windflow into forest canopy edge, combustion and fire-spread in porous particle bed, and relevant local fluid mechanics and heat transfer.

Short Description: An analytical approach is being explored using field data, if available, and considering specific field studies in a later stage.

Instrumentation: None for field studies.

5. R. Ekblad, Forest Service, Equipment Development, Missoula, Montana

Current/Planned Research: Modeling of aircraft wake-droplet interaction for aircraft selection, fixed wing and helicopter, with particular emphasis on spray release in mountainous terrain.

Short Description: Ballistic approach for near-field effect of fixed wing and/or helicopter on aerial low level release from different locations.

Instrumentation: Tethersonde balloon system.

6. J. Bergen, Forest Service, Pacific Southwest, Riverside, California

Current/Planned Research: Analytical and numerical modeling of transport, and nonuniform boundary layer above canopy, study of relationship between heat transfer and drag coefficient, and characterization of California ASCOT site vegetation.

Short Description: Canopy transport modeling is based on parameterization of secondary flows, turbulence statistics and mass, momentum and energy balance. Modeling of nonuniform boundary layer above canopy is approached by means of a generalized integral analysis.

Instrumentation: see 3 above.

7. D. Sloop, Army Chemical Systems Laboratory, Aberdeen Proving Ground, Maryland

Current/Planned Research: Modeling of threat assessment.

Short Description: A variety of numerical models based on statistical, deterministic and Monte-Carlo simulation.

Instrumentation: N/A.

8. M. Myirski, Army Chemical Systems Laboratory, Aberdeen Proving Ground, Maryland

Current/Planned Research: Diffusion in forest terrain and modeling of hazard analysis from potential chemical munition accidents.

Short Description: Gaussian type of modeling.

Instrumentation: N/A.

9. G. McWilliams, Army Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico

Current/Planned Research: Initiation of models that characterize the meteorological conditions and turbulent diffusion coefficients in urban domain.

Short Description: Models presently utilized are based on empirical data and wind-tunnel simulation studies.

Instrumentation: N/A

10. F. V. Hansen, Army Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico

Current/Planned Research: Microscale air pollution in the range of 100 m to a few kilometers, smoke screening of large areas, optimum impact separation of smoke munitions and expenditures.

Short Description: Computer simulation of atmospheric optics and diffusion models.

Instrumentation: General instrumentation for measurement of micro-amd meso-meteorological parameters, optical measurements, lidar system.

11. W. D. Ohmstede, Army Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico

Current/Planned Research: Diffusion, parameterization, source characteristics.

Short Description: Eulerian-Lagrangian modeling.

Instrumentation: N/A.

12. R. K. Dumbauld, H. E. Cramer Company, Salt Lake City, Utah

Current/Planned Research: Contractual applied research for ASL and FS; complex terrain model validation and development of turbulence profile above canopies for ASL; development and improvement of aerial spray drift and deposition models for FS.

Short Description: Terrain wind field models and gaussian type dosage, concentration and deposition based on mass continuity and any other acceptable physical principles. Emphasis is placed on development of computer programs.

13. R. M. Cionco, ASL; D. G. Fox, RMF&RES; W. Z. Sadeh, CSU.

The members of the Steering Committee are involved in various aspects of analytical and numerical modeling, field studies and physical simulation studies as indicated in the general lectures delivered by them.

4. DELIBERATIONS

The deliberations, that took place during the second day of the working meeting, concentrated on the present status of modeling of airflow in canopy and urban domains. Most of the discussions focused on modeling of flow in canopy domains since modeling of flow in urban domain is in an early stage of development. In addition, comments on various field studies in complex terrain presently being carried out (e.g., the Mount San Antonio Study in northcentral New Mexico conducted by RMF&RES) were made. The specific comments of the attendees are not fully summarized in this document. Only the main issues relevant to the basic objective of the working meeting, viz., a comprehensive field study, are briefly summarized herein.

The discussion clearly revealed that it is a general agreement concerning the need for a comprehensive field study of meteorological and diffusion characteristics in wooded and urban domains in complex terrain. In order to specifically identify the needs for a field study and modeling, a field/modeling study matrix form was completed by all the participants. A sample of this form is given in Appendix IV. A review of these forms further indicated the consensus for a field study.

Next, the discussion strikingly pointed out that both the Atmospheric Sciences Laboratory and the Forest Service have identical pressing needs for a database and model development. It was further agreed that a cooperative field study is a sensible and practical approach to produce a comprehensive and unified database on meteorological and diffusion characteristics. All participants subsequently stressed the benefits for both parties that will result from undertaking a joint field study. In view of this commonality of needs, a unanimous agreement for initiating a cooperative field study was reached. Thus, the general recommendation of the working meeting is:

> *"A cooperative field study between the US Army Atmospheric Sciences Laboratory and the Forest Service on meteorological and diffusion characteristics in wooded and urban domains in complex terrain should be initiated, organized and conducted."*

5. FIELD STUDY

A great deal of discussion was devoted to the various aspects of the joint field study. Comments focused on planning a field study that will include both canopy and urban domains within micro- and meso-scale range. As a result, the discussions addressed the following main points: (1) basic requirements for selecting a field site; (2) variables to be measured; (3) measurement technique; (4) tentative field sites; (5) management and coordination; and, (6) future activities. A summary on the consensus reached concerning these aspects and associated recommendations is given herein.

5.1 Requirements

The essential criteria concerning the complex terrain characteristics, scale and airflow which are to be met concurrently in selecting a field site are:

1. Moderately complex terrain
2. Vegetative domain - forest canopy (clearing, edges), agricultural canopy
3. Urban domain - inner city surrounded by industrial area, suburban area and rural area
4. Contour gradient of about 700 m/10 km
5. Moderate valleys, ridges
6. Microscale range - local and regional scale
7. Mesoscale range
8. Relatively well defined airflow
9. Reasonable upwind fetch with respect to the surface roughness
10. Acceptable variability of airflow conditions
11. Seasonal variability - fall, winter, spring, summer
12. Drainage winds

5.2 Variables

Parameters to be measured are:

1. Terrain characteristics
2. Canopy roughness characteristics - height, distribution (density), fetch, shape, clearing, edges
3. Urban roughness characteristics - shape, height, distribution, fetch

4. Wind speed and direction - vertical and horizontal profile
5. Turbulent velocity components
6. Turbulence characteristics
7. Temperature - vertical and horizontal distribution
8. Surface temperature - terrain, leaf, building
9. Mixing depth
10. Heat flux
11. Radiation
12. Pressure
13. Moisture
14. Diffusion characteristics
15. Concentration
16. Lagrangian variables

5.3 Measurement Technique

Suggestions concerning measurement technique and instrumentation are, at this point, of general nature in view of the preliminary stage in the planning of the field study. More specific measurement techniques and instrumentation, along with the desired accuracy and resolution, will be recommended in due time after the selection of a site and with the completion of the planning. Several basic recommendations are nevertheless listed below.

1. Landstat data for terrain characterization
2. Surface stations and meteorological towers equipped with instrumentation for measurement of micrometeorological parameters; a minimum of 20 stations distributed over the entire field site are suggested
3. Remote Automated Weather System (RAWS) stations
4. Tethersonde balloon systems
5. Rawinsonde, radiosonde, and other types of upper air measurement devices

6. Acoustic sounder

7. Tracking Radar multiple tetroon system

8. Laser Doppler anemometers

9. Hot-wire anemometers

10. Ground and aerial release of tracers (or agents) - point and line sources, instantaneous and continuous release

11. Tracer sampling network - near the source inside forest canopy, agricultural canopy and urban area, and over a range up to beyond 100 km from the source

12. Photographic surveys of plumes

13. Satellite meteorological data

14. Physical modeling of field site

15. Data loggers, data acquisition systems, electronic equipment, and other necessary instrumentation

5.4 Field Sites

A fair amount of discussion was oriented around the selection of a field site that meets the necessary requirement outlined in Sect. 5.1. A decisive criterion in selecting a site was a moderately complex terrain configuration that contains canopy and urban domains. An additional criterion was site availability of support facilities and/or laboratory. At this time, eight tentative sites have been proposed. These eight field sites are listed below in alphabetical order:

1. Boise, Idaho
2. Eugene, Oregon
3. Huntsville, Alabama
4. Idaho Falls, Idaho
5. Little Rock, Arkansas
6. Los Alamos, New Mexico
7. Rapid City, South Dakota
8. Sacramento/Auburn, California

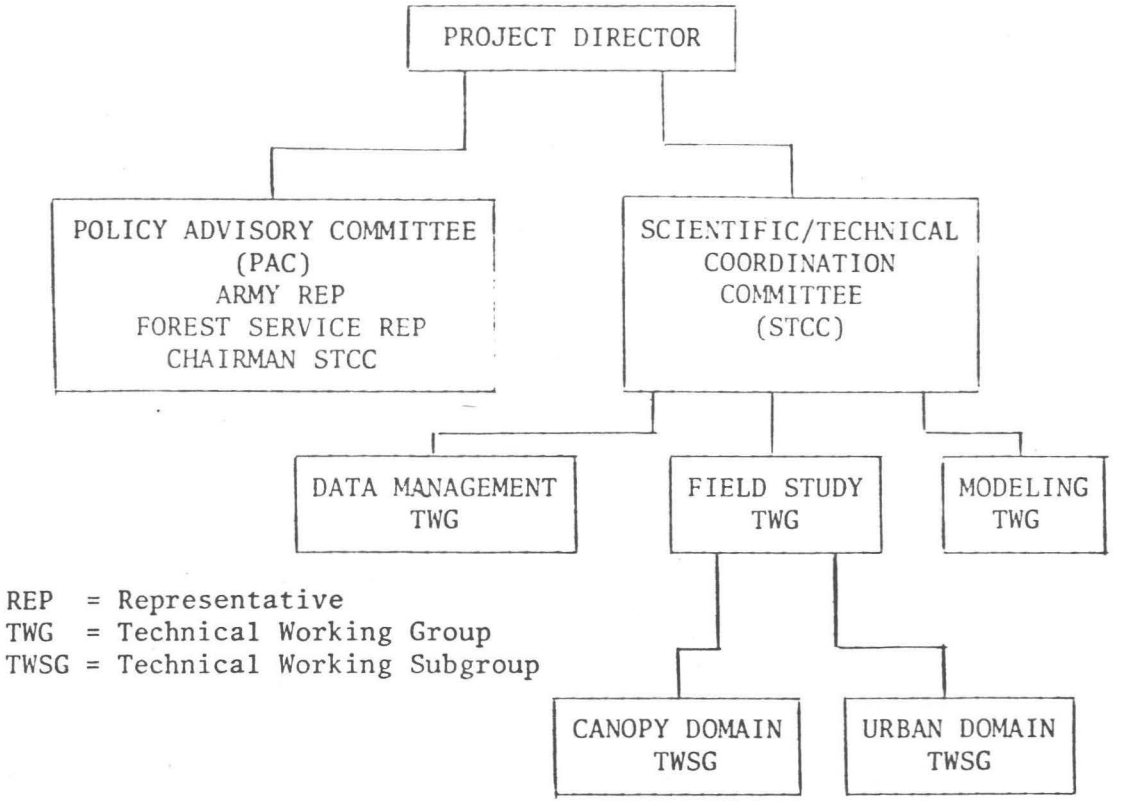
A preliminary evaluation of these sites is planned in order to provide all the necessary basic data for selecting a field site consistent with the requirements advanced in Sect. 5.1. This preliminary evaluation will be performed by Mr. G. McWilliams, ASL. Physical modeling in a meteorological wind tunnel of the field site for determining the optimum siting of surface stations, meteorological towers, RAWS stations, location of tracer sources and sampling network, and for investigation of critical flow situations is recommended.

5.5 Management and Coordination

A great deal of discussion focused next on the management and coordination of the cooperative field study. The proposed field study is to be conducted as a cooperative project of the Atmospheric Sciences Laboratory and Forest Service, and it is very diverse in its activities. In view of the joint nature of the field study, the principles for interagency cooperation and for management should be clearly established early in the program. To this end, it is important to define management philosophy and to submit a tentative organizational structure. The required management philosophy is to maintain an agreed upon centralized administrative control, and centralized scientific and technical coordination. Centralized control and coordination are needed to ensure that the objectives of each subprogram are consistent with the overall goals of the project and that each subprogram is carried out according to an established general plan. Additional aspects that require centralized coordination are documentation of the field study, determination of data collection techniques, establishment of needed data accuracy and resolution, and data management. Next, data management includes: (1) data reduction in a standard format which has to be established; (2) data archiving; (3) data documentation; (4) creation of database; and, (5) evaluation of database.

Based on this management philosophy, a tentative organizational scheme is suggested. In advancing an organizational structure, consideration was given to the joint nature of the field study and the need for an efficient organization. The proposed organizational structure consists of: (1) Project Director; (2) Policy Advisory Committee composed of an Army Representative, a Forest Service Representative and a third member who is a scientist nonaffiliated with either agency (an independent) and who will also chair the Scientific/Technical Coordination Committee; (3) Scientific/Technical Coordination Committee; (4) Field Study Technical Working Group consisting of a Canopy Domain Technical Working Subgroup and an Urban Domain Technical Working Subgroup; (5) Data Management Technical Working Group; and, (6) Modeling Technical Working Group. This organizational structure is illustrated in the diagram below. At this time no recommendations concerning the specific composition of the various committees and technical working groups and subgroups are advanced.

In order to pursue the activities initiated at this working meeting, the group decided to appoint a small action oriented steering committee. It was unanimously agreed to ask the Steering Committee of the Working Meeting to serve as the Acting Steering Committee of the project. Thus, the group recommended to form an Acting Steering Committee composed of R. M. Cionco (ASL), D. G. Fox (RMF&RES) and W. Z. Sadeh (CSU). Steering committee members should be funded to assure that they will have adequate time to devote to their duties and activities. The charges to the Steering Committee are: (1) publication of a short summary report on the proceedings of the working meeting; (2) to coordinate the completion of the preliminary evaluation of the field sites; (3) to convene a second



working meeting in Spring 1983; (4) to pursue the planning of the cooperative field study; (5) to establish guidelines for the cooperation between the Atmospheric Sciences Laboratory and Forest Service; (6) to submit a consolidated proposal on the organizational structure of the program; (7) to insure and provide ongoing communication within and outside of the program.

5.6 Future Activities

It was the consensus of the group that activities necessary to complete the planning of the cooperative field study and to ensure its execution in FY 1985 are to be pursued. To start with, a Second Working Meeting will convene at Pacific Southwest Forest & Range Experiment Station in Riverside, California, Wednesday and Thursday, 30 to 31 March 1982. The goals of the Second Working Meeting are to: (1) synthesize the various objectives and approaches into an integrated plan; (2) select a field site; (3) establish the organizational structure; (4) review and determine the resources needed to execute the field study; (5) establish measurement techniques and procedures; and, (6) review the needed instrumentation.

A tentative plan of activities beyond the Second Working Meeting is outlined below.

Time	Activity	Objective
Fall 1983	Third Working Meeting	To finalize field study workplan
Spring 1984	Fourth Working Meeting	Inspection of field site, selection of measurement sites, testing of field instrumentation, establishment of data management
Fall 1984	Fifth Working Meeting	Completion of all details of the workplan, installation of equipment
Fall 1984	Field	Data collection, reduction, documentation, analysis, evaluation, model exercising
Winter 1985	Study	
Spring 1985		
Summer 1985	Cycle	
Fall 1985	Complete component of database Exchange of data packages Compilation of database Dissemination of database Publication	

6. CONCLUDING REMARKS

The working meeting convened to examine the feasibility of a cooperative field study between the Atmospheric Sciences Laboratory and the Forest Service devoted to producing a comprehensive and unified database on meteorological and diffusion characteristics in wooded and urban domains in complex terrain. Aspects related to the needs of both agencies were reviewed and discussed, and the areas of mutual interest were identified. The basic recommendation of the working meeting is that *a cooperative field study should be initiated, organized and conducted.* Additional recommendations and preliminary suggestions concerning criteria for selection of a field site, variables to be surveyed, measurement technique and instrumentation, tentative field sites, management and coordination, and future activities are submitted. An acting Steering Committee consisting of three scientists was appointed and charged to further the activities initiated at this working meeting. A second working meeting, devoted to propose an integrated workplan for the field study, will convene in Riverside (PSWF&RES) in March 1983.

The cooperative field study on meteorological and diffusion characteristics in wooded and urban domains in complex terrain proposed here may be expected to produce the database needed for development, testing, calibration, evaluation and validation of integrated mesoscale-microscale models. It is apparent that this longing for database will be invaluable for the growth of both basic and applied research conducted by the Atmospheric Sciences Laboratory, the Forest Service, in Universities, and in other agencies. This database will provide the input for achieving improved modeling of and prediction ability on airflow and transport processes in complex terrain. The participants in this working meeting strongly recommend that the proposed cooperative field study proceed with due sense of urgency, and call on the various agencies to provide the resources needed to ensure the successful completion of this invaluable and unique project.

APPENDIX I

ROSTER OF PARTICIPANTS

Name	Affiliation	Address	Phone
F. A. Albini	Forest Service Northern Forest Fire Laboratory	Drawer G Missoula, MT 59806	(406) 329-3485 FTS 585-3485
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W. Z. Sadeh	Colorado State University Civil Engineering Department	Fort Collins, CO 80523	(303) 491-8573
D. Sloop	Army Chemical Systems Laboratory	DRDAR-CLY-A Aberdeen Proving Ground, MD 21010	(301) 671-3570

E. H. Holt Samuel Cionco

APPENDIX II

WORKING MEETING

ON

METEOROLOGICAL AND DIFFUSION CHARACTERISTICS IN

WOODED AND URBAN DOMAINS IN COMPLEX TERRAIN

Army Atmospheric Sciences Laboratory
White Sands Missile Range, New Mexico
16-17 November 1982

AGENDA

Tuesday, November 16, 1982

Session No. 1 8:30 a.m. - 12:00 p.m.

Chairman: R. M. Cionco, ASL

8:30 - 8:45	Welcome Remarks-Dr. E. H. Holt, Chief, Atmospheric Research Division, ASL
8:45 - 9:00	Working Meeting Objectives-R. M. Cionco, ASL
9:00 - 9:50	Army Needs in Meteorology and Diffusion in Complex Terrain-R. M. Cionco, ASL
9:50 - 10:00	Coffee Break
10:00 - 10:50	Overview of Forest Service Atmospheric Sciences Needs-D. G. Fox, RMF&RES
10:50 - 11:40	Research Opportunities in Meteorology and Diffusion in Complex Terrain-W. Z. Sadeh, CSU
11:40 - 12:00	Discussion
12:00 p.m.	Lunch

Session No. 2 1:00 p.m. - 5:00 p.m.

Chairman: W. Z. Sadeh, CSU

1:00 - 3:00	Informal Presentation on Current/Planned Research Projects-each participant (15 min per presentation)
3:00 - 3:15	Coffee Break
3:15 - 5:00	Informal Presentations
6:30	Informal Dinner

Wednesday, November 17, 1982

Session No. 3 8:30 a.m. - 2:45 p.m.

Chairman: D. G. Fox, RMF&RES

8:30 - 9:00	Cooperative Field Study: Objectives, Feasibility, Participation, Interaction, Planning-R. M. Cionco, ASL, D. G. Fox, RMF&RES, W. Z. Sadeh, CSU
9:00 - 10:00	Open Discussion
10:00 - 10:15	Coffee Break
10:15 - 12:00	Open Discussion
12:00 p.m.	Lunch
1:00 - 2:45	Open Discussion
2:45 - 3:00	Coffee Break

Session No. 4 3:00 p.m. - 5:30 p.m.

Chairman: W. Z. Sadeh, CSU

3:00 - 5:00	Open Discussion
5:00 - 5:30	Concluding Remarks: Cooperative Field Study-R. M. Cionco, ASL, W. Z. Sadeh, CSU

APPENDIX III

QUESTIONNAIRE

NAME

AFFILIATION

POSITION

1. WHAT ARE YOUR ONGOING/PLANNED PROJECTS?

   1.1 OBJECTIVE

   1.2 APPROACH

2. FIELD STUDY

   2.1 SHORT DESCRIPTION

   2.2 TIME & SITE CONSTRAINTS (If any)

   2.3 INSTRUMENTATION CAPABILITY

   2.4 STATUS OF DATA COLLECTION & REDUCTION

   2.5 WHEN RESULTS WILL BE AVAILABLE?

3. MODELING

   3.1 BRIEF DESCRIPTION

   3.2 WHAT MODEL(S) ARE YOU UTILIZING?

   3.3 ON WHAT PRINCIPLES THE MODEL(S) IS(ARE) BASED?

3.4 PRESENT STATUS OF YOUR MODELING EFFORT

3.5 HARDWARE

3.6 SOFTWARE (CODING)

3.7 WHEN RESULTS WILL BE AVAILABLE?

3.8 VALIDATION STATUS

4. Lab Simulation

4.1 SHORT DESCRIPTION

4.2 FACILITY

4.3 TYPE OF SIMULATION

4.4 BASED ON FIELD DATA?

4.5 PRESENT STATUS

4.6 AVAILABILITY OF RESULTS

4.7 COMPARISON WITH FIELD DATA

4.8 COMPARISON WITH MODEL(S)

FIELD/MODELING STUDY MATRIX FORM

	NEEDS / ORG'N	MET DATA					DISPERSION DATA					MODELING				
		C	U	MIC	MES	T/D	C	U	MIC	MES	T/D	C	U	MIC	MES	T/D
ARMY	ASL															
	CSL															
FOREST SERVICE	FTC															
	RIV															
	DAV															
	MIS															
	POR															

ASL - Atmospheric Sciences Laboratory
CSL - Chemical Systems Laboratory
FTC - Fort Collins, Colorado
RIV - Riverside, California
DAV - Davis, California
MIS - Missoula, Montana
POR - Portland, Oregon

C - Canopy
U - Urban
MIC - Microscale
MES - Mesoscale
T/D - Transport/Diffusion